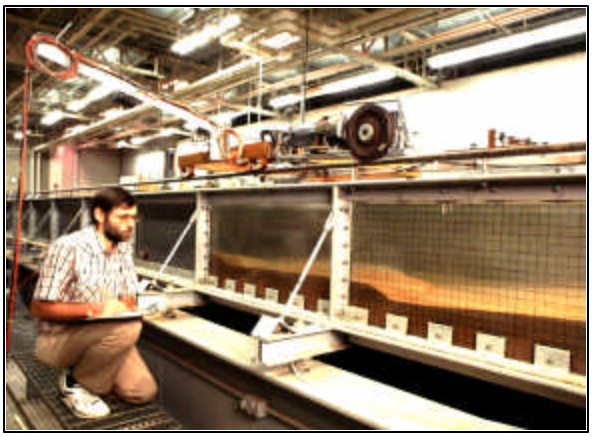
USDA UNITED STATES DEPARTMENT OF AGRICULTURE

Agricultural Research Service

National Sedimentation Laboratory

Summary of Research Activities

April 2004



Providing watershed stewardship for the 21st century

P.O. Box 1157, 598 McElroy Drive
Oxford, MS 38655
Tel. (662) 232-2900

United States Department of Agriculture

Research, Education and Economics
Agricultural Research Service

Dear Visitor,

This in-house prepared program booklet summarizes, in simple language, the principal research activities at the National Sedimentation Laboratory (NSL). It was composed in response to a need to offer the many visitors to the Laboratory and Web page searches a more coherent and complete picture of the on-going research program at the NSL. The material has been presented in a thematic manner. As you will note upon perusing this booklet, the research at the NSL covers a wide spectrum of problems in the areas of soil erosion, conservation, sediment transport, and sedimentation as well as sediment and agricultural runoff related water quality and ecology issues. While most of the research at the NSL is focused on seeking solutions to problems, it also has very substantive fundamental and modeling research components.

We hope that the information of this research program booklet is informative, helpful, and instructive. We welcome the opportunity to collaborate with any scientist with similar interests so that the synergy of this cooperation will lead to a better service to our stakeholders and the public at large.

M. J. M. Römkens
Laboratory Director

National Sedimentation Laboratory
598 McElroy Drive
P.O. Box 1157, Oxford, Mississippi 38655
Voice: 662 232-2901 ● FAX: 662 232-2915 ● E-mail: mromkens@msa-oxford.ars.usda.gov

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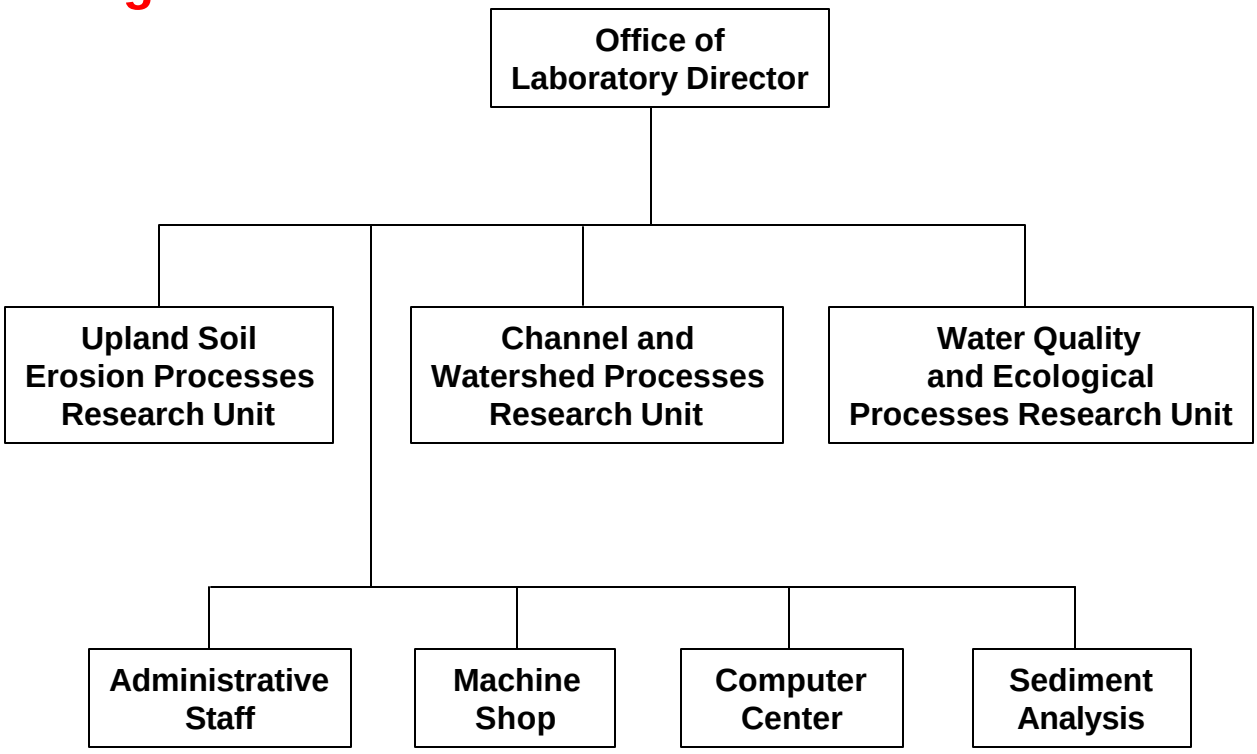
1. NSL Mission

The research program at the National Sedimentation Laboratory (NSL) emphasizes interdisciplinary research dealing with (1) the processes of soil erosion, transport and deposition, (2) the movement of chemicals on upland areas and in streams, (3) the impact of agricultural practices, in-stream structures, and bank protection on these processes, (4) water quality issues related to agricultural practices, and (5) the ecological well-being of stream habitats and adjacent riparian zones. Research ranges from basic and fundamental research to applied research and technology transfer to federal and state action agencies. Of special significance is cooperative research with the USDA-Natural Resources Conservation Service (NRCS) in the Conservation Effects Assessment Project (CEAP). Cooperative research has also been conducted with the U.S. Army Corps of Engineers (COE) in the multi-agency Demonstration Erosion Control (DEC) Project; with the USGS and Mississippi State University in the Mississippi Delta Management Systems Evaluation Area (MSEA). Cooperative research is on-going with the Mississippi Department of Environmental Quality and the U.S. Environmental Protection Agency on TMDL research. Much of the research conducted by the NSL is in cooperation with the University of Mississippi, the Mississippi Agricultural and Forestry Experiment Station, and other universities. This cooperation has allowed NSL to conduct research related to bio-indicators, numerical modeling, and acoustical measurements and to make progress that would not occur otherwise.

USDA-ARS National Sedimentation Laboratory.

2. Organization



3. Personnel

18 Scientists and Engineers (Ph.D. level)
- 4 Hydraulic Engineers
- 3 Agricultural Engineers
- 3 Geologist
- 2 Soil Scientists
- 1 Physicist
- 1 Chemist
- 3 Ecologists
- 1 Agronomist
- 1 Hydrologist

9 Support Scientists (B.S. or M.S. level)

22 Technical Staff Members

9 Administrative Staff Members

4. Research Facilities

1. **Hydraulic Laboratories**
2. **Physical and Chemical Laboratories**
3. **Experimental Watersheds**
    - **Goodwin Creek Experimental Watershed (20 km^2)**
    - **Mississippi Delta MSEA Watersheds (20-1600 ha)**
    - **MAFES Holly Springs Experimental Station**
4. **Machine Shop**
5. **Computer Center**

5. Principal Cooperating Institutions and Agencies

University of Mississippi (MAFES)
- National Center for Computation Hydroscience and Engineering
- National Center for Physical Acoustics
- Biological Field Station

Mississippi State University
Alabama A&M University (1890 Institution)
Alcorn State University (1890 Institution)
Arkansas State University
North Carolina A&T University (1890 Institution)
North Carolina State University
Ohio State University
Princeton University
University of Connecticut
University of Illinois
University of Iowa
University of Minnesota
University of Washington

National Oceanic and Atmospheric Administration
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
U.S. Geological Survey
USDA-Natural Resources Conservation Service
Mississippi Department of Environmental Quality

University of Louvain, Belgium
University of Nottingham, England
University of Leeds, England
Center for Agricultural Landscape and Land Use Research (ZALF), Germany
Public University of Navarra, Spain

Besides these institutions, many informal working relationships exist within scientists at other USDA-ARS locations, universities, and federal and state agencies.

6. CRIS Projects

Research is performed in the context of mandated CRIS (Current Research Information System) projects. Current projects are:

1. **Processes, control, and prediction of erosion and runoff on upland areas in agricultural watersheds. (Upland Erosion Processes Research Unit)**

2. **Integrated analysis of landscape processes for the management of agricultural watersheds. (Channel and Watershed Processes Research Unit)**

3. **Environmentally sound stream corridor rehabilitation and management in agricultural watersheds. (Water Quality and Ecological Processes Research Unit)**

4. **Economically sound farm and offsite management practices for improving water quality. (Water Quality and Ecological Processes Research Unit)**

Projects are reviewed by a panel of non-ARS scientists, last 5 years, and require annual reports which are accessible on the internet to any one (www.usda.ars.gov).

Project approval depends on soundness of science and due consideration is given to impact, capacity, and relevancy.

Project may involve university faculty and graduate students and cooperators from other ARS locations and Government and State agencies.

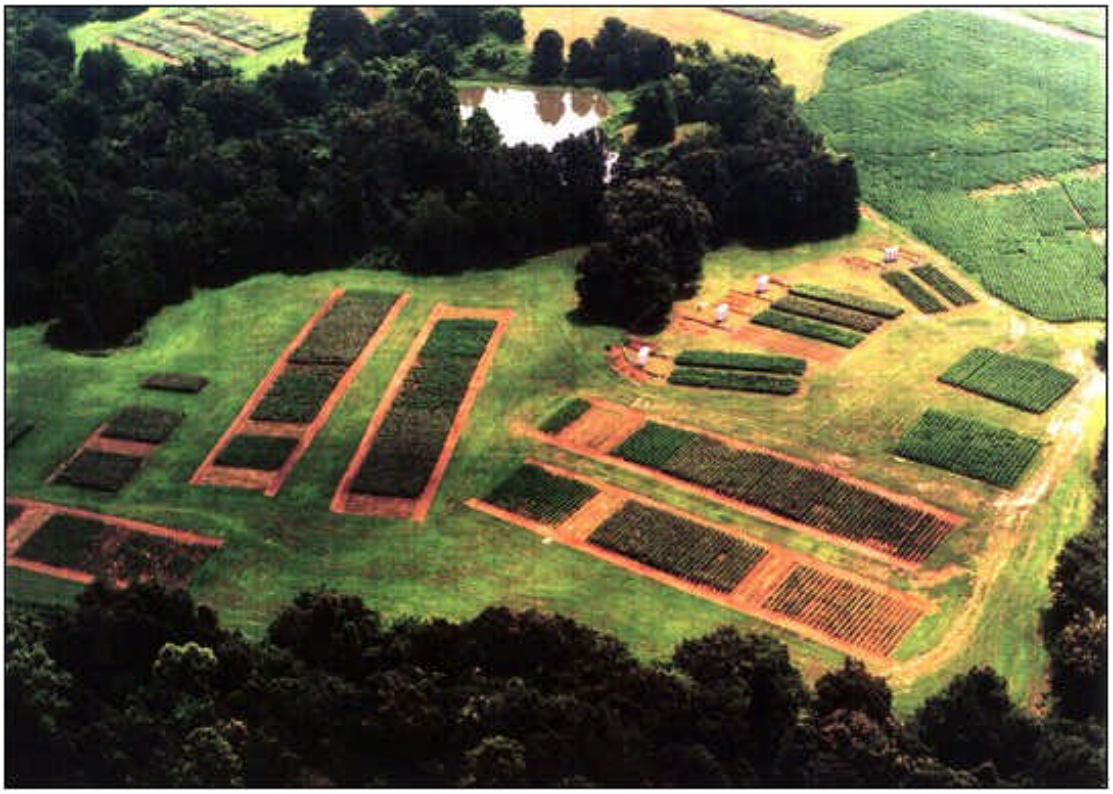
7. Historical Perspective

The National Sedimentation Laboratory was established in 1956 and opened in 1959. Senate document #59 of the 86th Congress charged that the NSL be the National Center for Sedimentation Research. Following is a list of major accomplishments.

1. **Design, development, and testing of low drop grade control structures, which have been widely used in the DEC watersheds.**
2. **Development of stream bank stabilization techniques, such as vegetative approaches, riprap, and bank toe protection.**
3. **Design and development of stream corridor restoration techniques with ecologically sound engineering approaches.**
4. **Application of bore hole method to determine the cohesiveness and permissible stress regime of bank material for channel stability determination.**
5. **Collection of large watershed databases from the Bluff Lines of Mississippi (Pigeon Roost, Goodwin Creek).**
6. **Contribution to the fundamental knowledge in sediment transport of bedload and suspended load in streams and rivers.**
7. **Reservoir sedimentation research, which includes the use of radioactive isotopes.**
8. **Conservation tillage research for the southeastern USA at Holly Springs (MAFES).**
9. **Major contributions toward the development of the Revised Universal Soil Loss Equation (RUSLE) and transfer of this technology to the NRCS.**
10. **Measurement of insecticide wash-off from plant canopies.**
11. **Quantification of effects of suspended and deposited sediment on aquatic ecosystems.**
12. **Research on fundamental processes and mechanics of soil erosion on upland areas.**
13. **Sediment yields and associated pesticide movement on flat areas in the Mississippi Delta.**
14. **Established that depth to subsurface soil layers can be used to assess erosion effects on soil productivity and soil quality.**

8. Upland Erosion Research

Achieving watershed-scale erosion control requires an integrated approach of good land management practices, stream protection and stabilization measures, and measures to enhance local terrestrial and aquatic ecosystems. Upland Erosion Research contributes to this goal by developing and testing farming and land use practices that allow farmers to use their land economically and productively in an environmentally sound manner. Cropping and land management practices that are based on a scientific understanding of all hydrologic, erosion, and runoff processes involved are tested on plot, field, and watershed scales. By quantifying these systems, and generalizing the findings in models and prediction technology, the widest possible use and dissemination of new information is achieved. Therefore, Upland Erosion Research consists of three interrelated components: Processes, Prediction, and Control.



Aerial photo of Nelson Farm illustrating runoff plots and watersheds where numerous studies on upland erosion processes are conducted.

8a. Crop and Tillage Management Systems

Upland Erosion Research consists of a wide range of studies aimed at developing environmentally friendly and economically feasible control and prevention methods using land and crop management systems. In the recent past, these studies included: (1) no-till farming systems that have received emphasis in recent years, (2) reseeding cover crops that reduce erosion, support weeds, and contribute nitrogen, (3) stiff grass hedges that trap sediment and stop headcuts, (4) soil amendments that improve aggregation and increase infiltration, and (5) terraces with outlets in grassed waterways. More recent studies include: (1) evaluation of the effectiveness of ultra-narrow row cotton with stiff grass hedges at reducing soil erosion and transport of agrichemicals, (2) evaluation of the effects of cropping history on long-term crop productivity and soil erosion of fragipan soils for no-till (NT) and conventional-till (CT) soybean, (3) evaluations of the ability of stiff grass hedges located, slightly off-contour with a 0.3 percent grade, at the downslope border of 5% sloping corn plots to divert runoff and reduce off-site soil loss. Erosion control research has resulted in improved soil erosion conservation practices, and fostered improvement and enabled validation of various aspects of the USLE, RUSLE, and WEPP erosion models.

Watershed research demonstrates how stiff grass hedges trap sediment.

Watershed research evaluating effectiveness of grass buffers.

No-till systems evaluated for erosion protection, productivity and profitability.

8b. Evaluating Soil Quality Degradation by Erosion

Soil quality is at an optimum level in the deepest and least eroded soils, but degradation occurs as the soil profile gradually decreases in thickness due to erosion. Soil degradation is a two-stage process. Initially, organic matter-rich surface horizons are removed leading to diminished nutrient supplying capabilities, water holding capacity, biodiversity, and aggregation. In the more deeply eroded phases, soil water storage capacity is a limiting factor due to shallow soil depth. For soils with no features that limit depth of water movement and root growth, soil loss has little effect on water storage capacity. Conversely, erosion is serious on soils that contain subsurface horizons such as fragipans, especially in years of below normal rainfall, because plant roots are restricted to the water stored in the soil volume above fragipan horizons. Research is being conducted to identify approaches to diminish the restrictive nature of fragipan horizons, increase effective soil depth, and enhance soil quality from the standpoint of improved yields and lower erosion losses.

Uneroded soil.

Slightly eroded soil.

Moderately eroded soil.

Severely eroded soil.

8c. Sediment Source Identification from Upland Areas in Watersheds

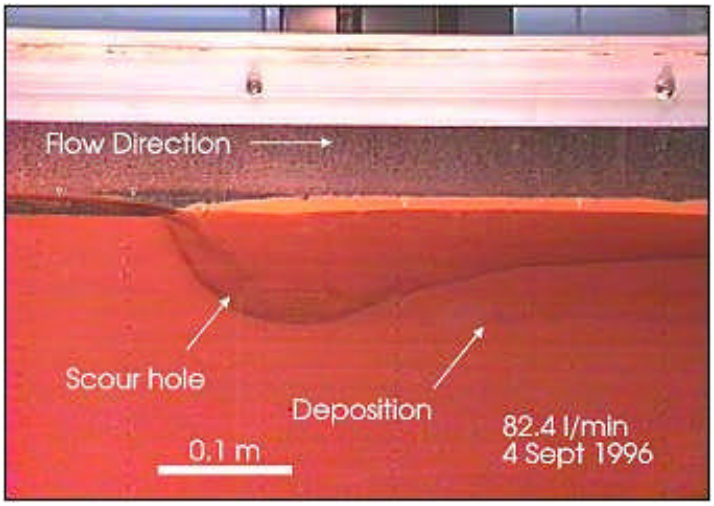
The ability to trace sediment back to a specific landscape segment will improve our understanding of sediment routing processes, identify areas where management systems need to be changed, and locate source areas of chemical pollutants. Watershed soil characterization approaches are being developed based on the relative acreages occupied by the individual soil types in the watershed. Soil characterization data for selected physical, chemical, and mineralogical properties are computed on the basis of a weighted average for the watershed. These data from individual sub-watersheds are compared to similar bedload and suspended sediment properties leaving the main watershed to determine which area is the primary contributor of sediment.

Sediment source areas can be highly variable depending on soil type and previous erosion.

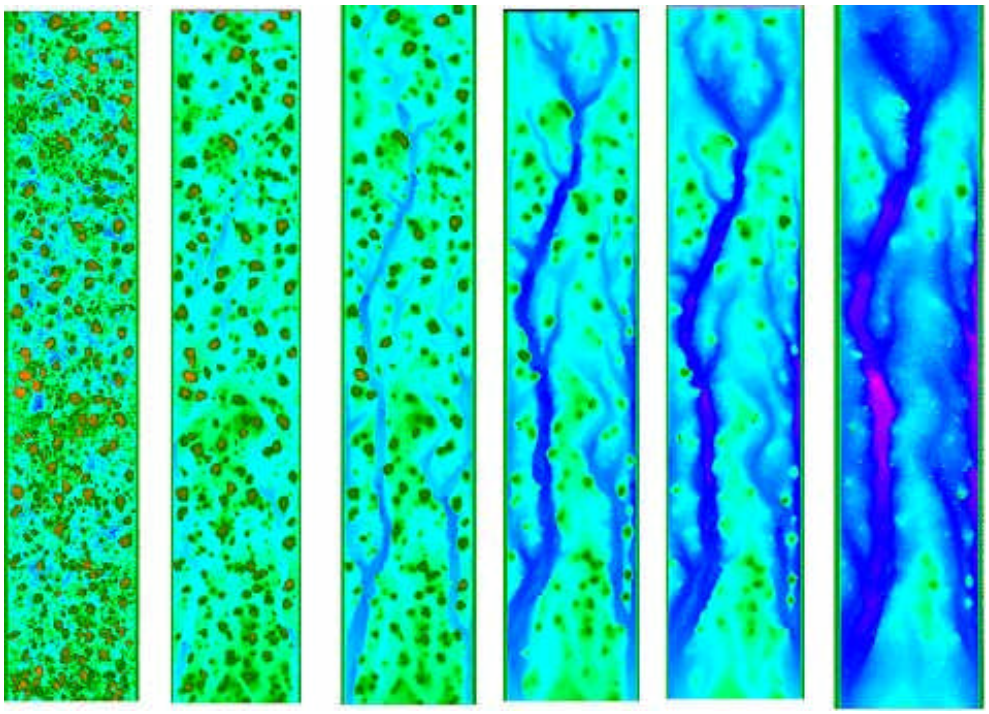
Sediment source areas can be determined using a series of analytical measurements.

8d. Headcut and Rill Development

Headcuts are places on fields where the most severe form of erosion is taking place. Their manifestations are usually observed as a sequence of sudden, small stepwise changes of several millimeters thickness in places of concentrated flow or as sudden changes of several centimeters thickness in rills and ephemeral gullies on upland areas. Field and laboratory research studies are being conducted to better understand the causes of headcut and rill development and to quantify this phenomenon in relation to (1) the characteristics of the overland or channel flow regime, (2) the geo-technical and soil mechanical or soil physical properties of the soil material, and (3) the stratigraphy and soil water pressures of the soil profile.



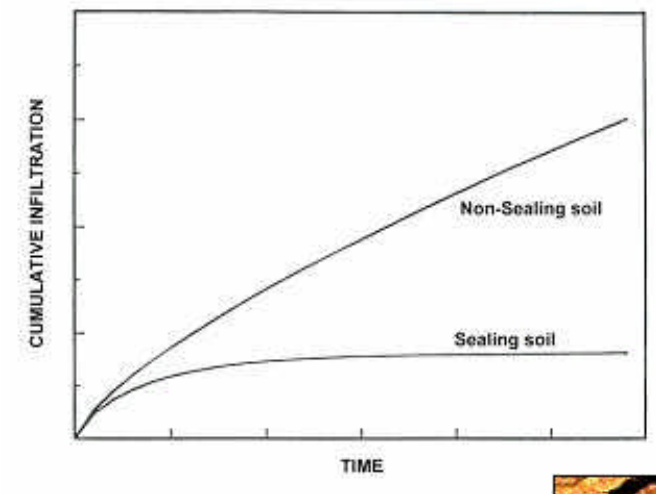
Headcut development in a flow typical of upland areas.



Rill development during a sequence of rainstorms on upland areas.

8e. Infiltration Research on “Real World” Soils

Soil erosion in watersheds begins the moment raindrops impact on soil surface and the detached particles are transported downslope by ensuing runoff. Soil erosion by runoff is to a considerable degree determined by the infiltration and surface retention characteristics of the soil and soil profile. These characteristics vary in time and space and change during and following a rainstorm event. Obtaining accurate estimates of rain infiltration under those conditions for real world soils is an extremely challenging task wrought with the complexities of varying and changing boundary conditions. Research is in progress that is designed to improve infiltration, and thus runoff, predictions for two types of soils: surface sealing susceptible soil, which impedes rain infiltration due to the structure destructive effect of impacting rain drops, and swelling/cracking soils in which rain water disappears into cracks during the early phases of a rainstorm until crack closure has occurred. The former class of soils often consists of poorly structured, highly erodible, medium textured soils commonly found in a sloping topography, such as the loess soils in the Mississippi Bluff Line watersheds. Soils of the second class are usually high-clay, bottomland soils commonly used in the south for cotton production, such as the Mississippi Delta, and thus are subject to agrichemical exposure with potentially damaging environmental consequences.

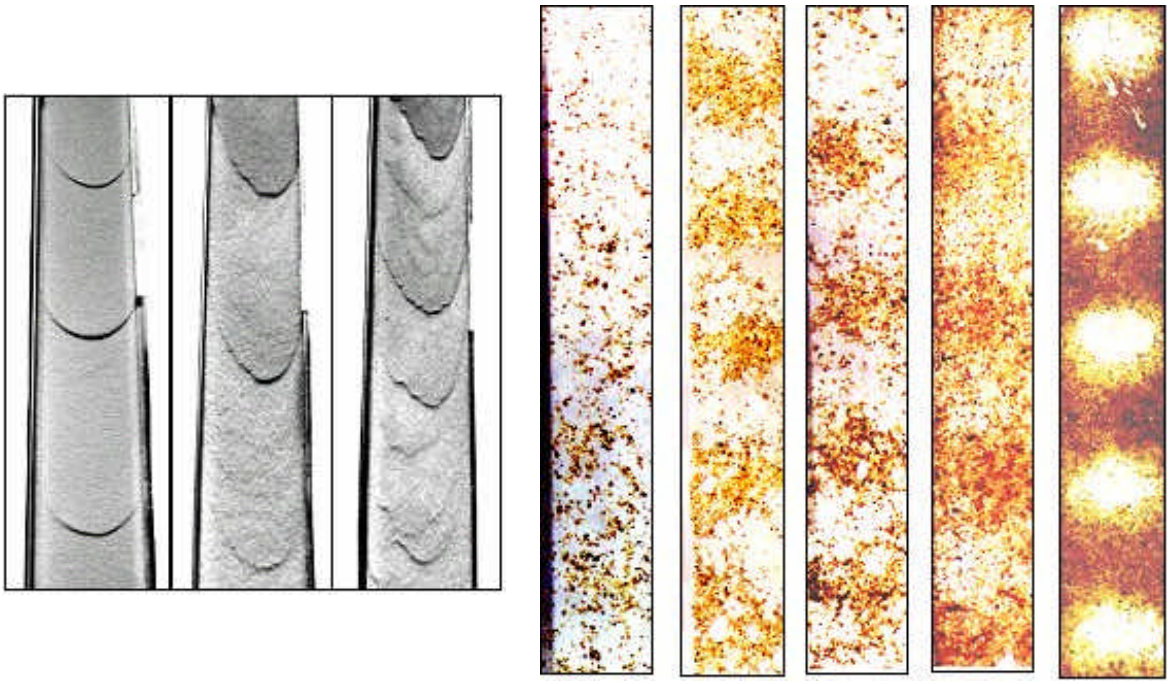


Infiltration into a soil for sealing and non-sealing surface conditions.

Soil surface of a cracking and swelling soils following a wetting and drying cycle.

8f. Sediment Transport in Shallow Overland Flows

Soil erosion is a complex phenomenon consisting of detachment and transport processes by rainfall and runoff. One of the least understood and inadequately quantified erosion processes is sediment transport in shallow flow on upland areas. Current descriptions of this process for these conditions have been adopted from the channel flow experience. They are based on excess shear or stream power in relation to their threshold values. Shallow flow is governed by the dominance of boundary effects and other complicating factors. One of those factors is the role of sediment itself. Laboratory studies have indicated that in shallow overland flow sediment moves in waves. These waves are thought to be a consequence of particle collisions in which kinetic energy is lost, particles coalesce at the upstream side, and are moved out of the crest at the downstream side of the wave by the flow energy. Where the flow is so shallow, that roll waves develop, the sediment particles are moved by the wave crest where the flow energy is concentrated. Laboratory studies are conducted to better understand the mechanics and the details of the processes involved so that more rational transport equations can be developed. Our observations indicate that the transport equations currently used are inappropriate for describing shallow overland flow and need to be improved to reflect the relevant mechanisms involved.



Developing sand waves in shallow flow.

8g. Soil Loss Prediction for Upland Areas (RUSLE)

The Revised Universal Soil Loss Equation (RUSLE) is the primary tool used by the NRCS as a farm planning tool to reduce soil loss on upland areas. RUSLE is an easily and widely used computer program that estimates rates of soil erosion caused by rainfall and associated overland flow. RUSLE has been developed and is maintained by the USDA-ARS in cooperation with the USDA-Natural Resources Conservation Service (NRCS), USDI-Office of Surface Mining, Reclamation, and Regulation, USDI-Bureau of Land Management, Soil and Water Conservation Society, and the University of Tennessee. RUSLE is used by numerous government agencies and private organizations and individuals to assess the degree of rill and interrill erosion, identify situations where erosion is serious, and guide development of conservation plans to control erosion. In the United States, NRCS is the principal user of RUSLE. RUSLE has been applied to cropland, rangeland, disturbed forest lands, landfills, construction sites, mining sites, reclaimed lands, military training lands, parks, land disposal of waste, and other land uses where soil is exposed to the erosive forces of raindrop impact and overland flow. The "official" USDA-Agricultural Research Service (ARS) Internet Web site for the Revised Universal Soil Loss Equation (RUSLE) is http://www.sedlab.olemiss.edu/rusle/index.html. Data files can be downloaded from this Internet site. The Internet site provides access to RUSLE documentation, application guides for RUSLE, and help contacts.

What is RUSLE?

- Set of mathematical equations that estimates average annual soil loss
- User provides input values that directly represent conditions at a specific site
- Rich data base available from which to choose input values
- Displays a wide range of computed values that give insight into the factors affecting soil loss

RUSLE can be used for soil loss prediction on fields with mixed land use.

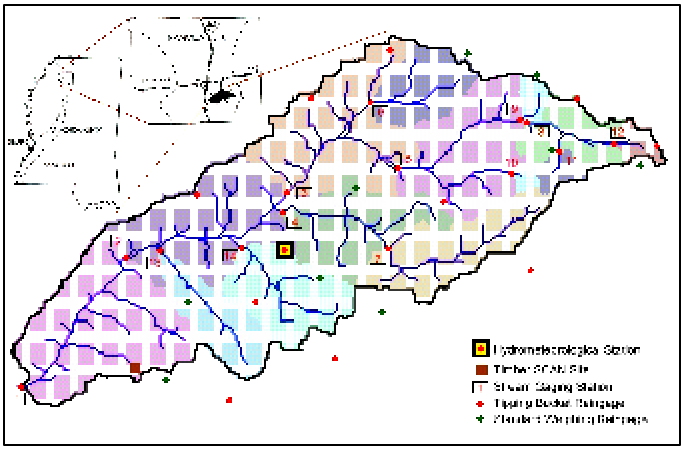
9. Channel and Watershed Research

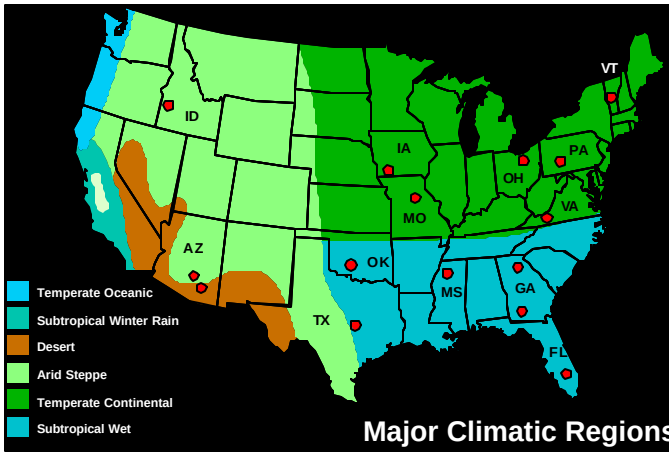
According to the US-EPA, over 300,000 miles of rivers and streams nationwide do not meet state water quality standards, and sediment has been identified as the primary pollutant. Greater societal attention is now placed on responsible environmental stewardship and watershed management. To meet these challenges, Channel and Watershed Processes Research seeks to provide the technology critically needed to rehabilitate and manage agricultural watersheds, to improve and maintain water quality standards and aquatic and riparian ecosystems, and to develop tools to predict future changes in watershed response due to changes in land use, hydrology, and engineering intervention. The focus of all field, laboratory, and theoretical work has been chosen to evaluate innovative best management practices and to fill the technological gaps in the USDA watershed models currently in use.

Photograph of the Goodwin Creek Experimental Watershed.

9a. Goodwin Creek Experimental Watershed

Goodwin Creek was established in north central Mississippi with construction funds provided by the US Army Corps of Engineers, Vicksburg District, and operated by the USDA National Sedimentation Laboratory since October 1981. Goodwin Creek is part of the ARS national network of 15 instrumented watersheds that serve as stable, high quality research platforms for process understanding, consistent historic databases, and magnets for scientific collaboration. Goodwin Creek is a 21.3-km^2, mixed land-use watershed that offers a 20-year database of climatologic, hydrologic, geomorphic, and sediment transport measurements. The Goodwin Creek database is extensively used by other Federal agencies and Universities. Several years of modeling research and testing on Goodwin Creek led to the development of the new AGNPS 2001 watershed management tool. AGNPS 2001 includes integration of field and channel erosion components and provides a functional watershed management tool for evaluating BMPs for agricultural producers and establishing watershed TMDLs.



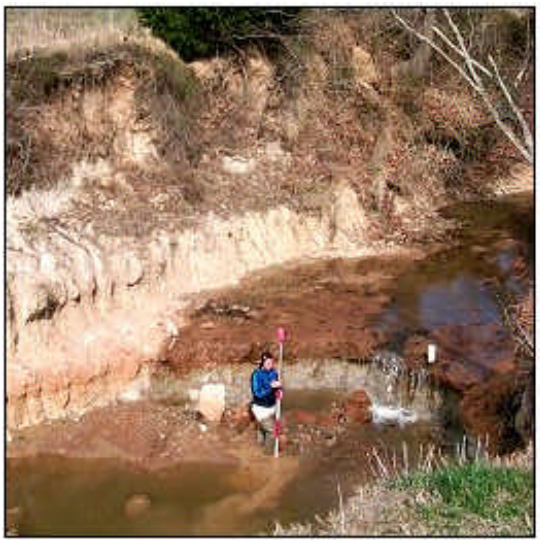


The database collected at the Goodwin Creek has been used extensively in the research of watershed processes.

9b. Yalobusha River Basin

The NSL is currently conducting a wide range of investigations within the 842-km^2 Yalobusha River watershed in northern Mississippi that target problems associated with gully and channel erosion particularly, bank collapse and the loss of agricultural land. This watershed, which is part of the DEC project, experiences accelerated upstream channel erosion and in the uplands, and frequent flooding downstream due to a plug of sediment and woody debris that has formed in the channelized river. The NSL has completed watershed-wide assessments of aquatic ecology, channel stability, and water quality. Results show that bank collapse accounts for a large proportion of the material in the debris jam.

The NSL is monitoring channel erosion and measuring the erodibility of clay-bed materials to improve predictions of erosion rates, and to help our partners target their channel protection work more effectively. The Corps of Engineers, Vicksburg District, one of our DEC partners, uses results on erodibility of resistant clay beds to formulate stabilization plans and construction designs, leading to cost savings in the millions of dollars. Results of channel evolution and bank-stability modeling provide alternative strategies for stabilization and alleviating downstream flooding problems.

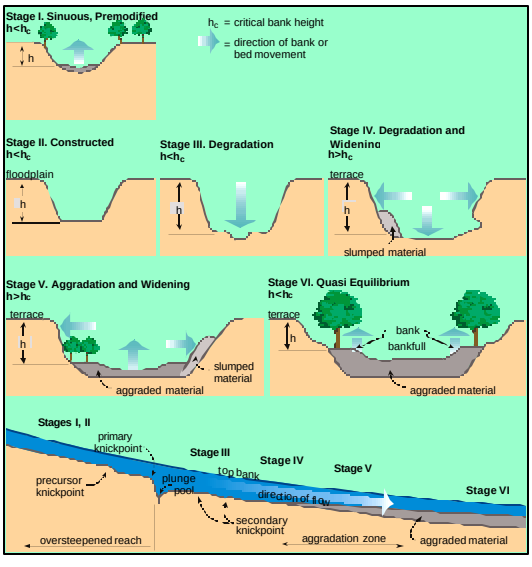


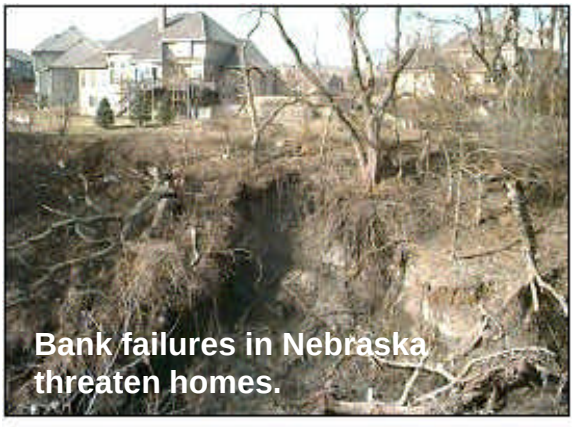
Surveying knickpoint migration and measuring streambed erodibility with ARS-designed instruments identifies areas in need of channel protection.

9c. Predicting Channel Change in Unstable Rivers

Thousands of kilometers of stream channels across the United States have been de-stabilized by a variety of mechanisms over the past 100 years and still erode at accelerated rates. Problems associated with this erosion include the downstream flooding problems, damage to infrastructure, degradation of habitat and water quality, and the loss agricultural land by streambank collapse. In fact, streambank erosion has been shown to be a principle source of sediment that impairs waterbodies in the United States. The NSL is currently conducting research in the field and through numerical modeling to better predict stream-channel changes and to provide new approaches to stabilize streams.

Using data from the Goodwin Creek Experimental Watershed, NSL scientists have developed a new streambank stability model that incorporates many features and processes that no previous model does to predict the timing and conditions of bank failures. The model has been used to provide stakeholders in Montana, Mississippi, Nebraska, and Iowa with detailed evaluations of ways to stabilize streambanks and prevent the loss of agricultural land. The role of different riparian-tree and grass species on enhancing streambank stability will be incorporated into the model by quantifying root reinforcement and the plants ability to remove soil water.




Bank failures in Nebraska threaten homes.

Identification of stage of channel evolution helps identify present and future locations of channel instability.

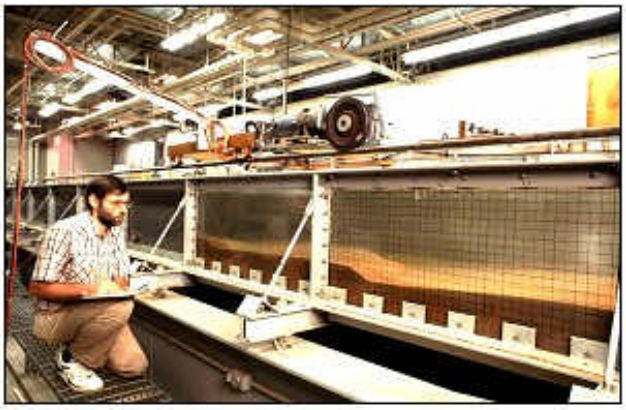
Measurements of the strength of tree roots are used to develop criteria for the stabilizing streambanks with vegetation.

9d. Erosion and Sedimentation Management in Watershed Stream Systems

All rivers and streams transport sediment, but land mismanagement can cause severe changes in hydrology and sediment load, adversely impacting farm productivity, flood control, infrastructure, and water quality and ecology. The ability to identify the sources of sediment, to understand how sediment moves, and to accurately measure, interpret, and predict the amount of sediment a stream or river carries is fundamental to better watershed management.

Research at the NSL focuses on small and large scale processes of sediment transport and river channel change. Hydraulic flumes are used to examine the processes of sediment entrainment and transport typical of upland areas, agricultural fields, and rivers. Intensive field research programs examine the processes responsible for the collapse of stream banks and long-term river adjustments to land mismanagement and channelization. These studies are used to construct and validate watershed management tools and technology.

Eroding banks can be a significant source of sediment in unstable streams.



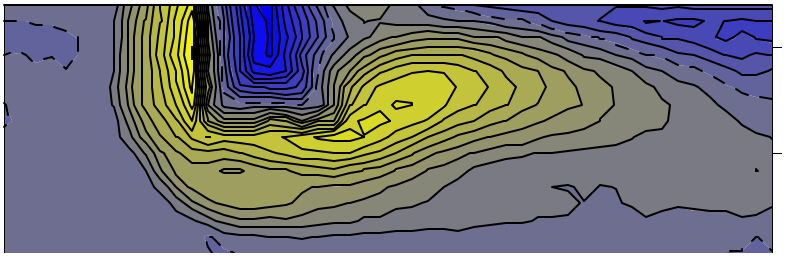
Laboratory experiments provide opportunities to study how sediment transport in rivers takes place.

In rivers and streams the bed is commonly composed of a mixture of sediment.

9e. Engineering Solutions for Stream Restoration

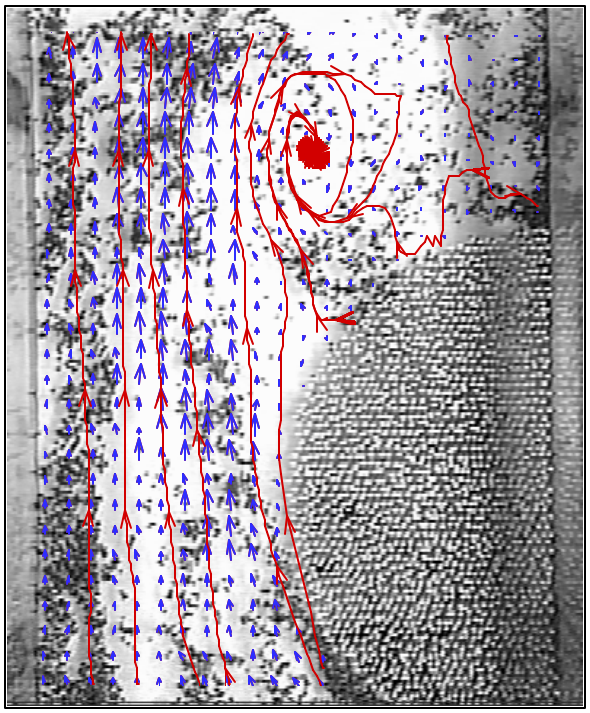
According to the US-EPA, over 300,000 miles of rivers and streams nationwide do not meet state water quality standards, and sediment has been identified as the primary pollutant. Greater societal attention is now placed on responsible environmental stewardship and watershed management. To meet these challenges, engineering solutions are needed to control channel erosion and degradation, to enhance environmental conditions and resources, and to rehabilitate streams and rivers using both traditional and modified structural designs.

Work is underway to optimize the design and placement of spur dikes for aquatic habitat enhancement, to design mitigation techniques for bank erosion using vegetation, and to develop techniques to assess the interactions between flow and riparian vegetation.



Spur dikes are designed to optimize streambank protection and aquatic habitat.

The geotechnical and hydrologic effects of vegetation on streambank stability are determined.



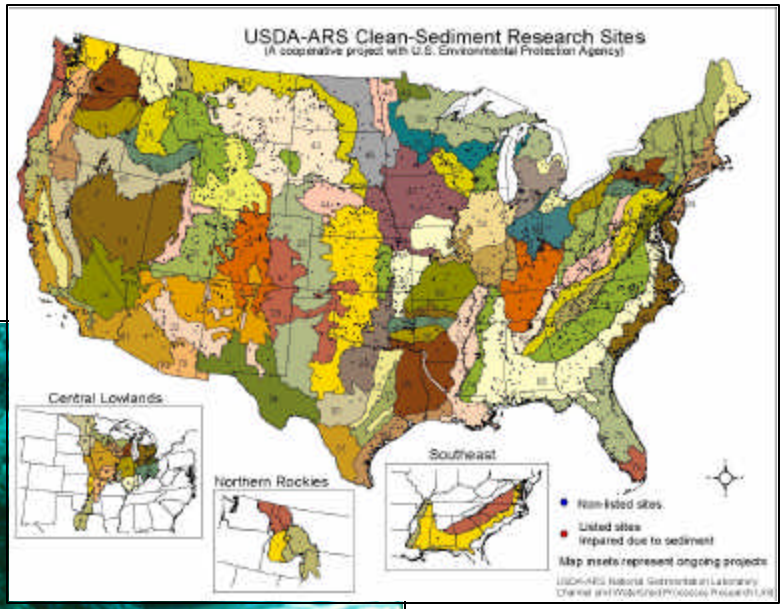
The impacts of riparian vegetation on stream channel flow and sediment transport are defined.

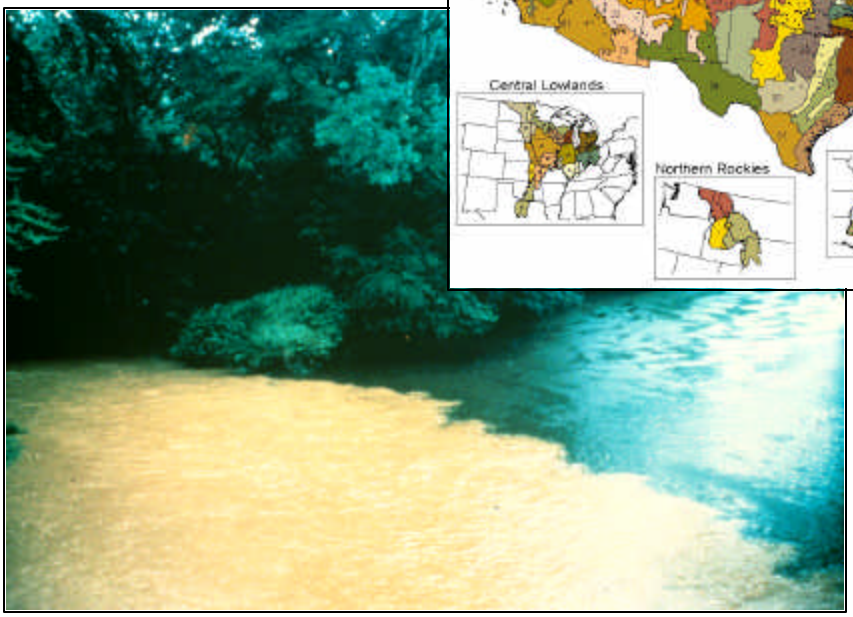
9f. Clean Sediment TMDL Research

Excessive erosion, transport, and deposition of sediment in surface waters is a major problem in the United States. The 1996 National Water Quality Inventory (Section 305(b) Report to Congress) indicates sediments are ranked as a leading cause of water quality impairment of assessed rivers and lakes. A national strategy is needed to develop scientifically defensible procedures to facilitate the development of Total Maximum Daily Loads (TMDLs) for clean (uncontaminated) sediment in streams and rivers of the United States.

In a cooperative project with the US Environmental Protection Agency (USEPA) and the Mississippi Department of Environmental Quality (MDEQ), researchers at the NSL are working to develop improved methodologies to evaluate the likelihood that a stream is impacted from a change in the amount of clean sediment. The main goal of this project is to define the linkages between the stage of channel evolution, the frequency and duration of sediment transport events, the biological integrity of a stream, and the rectification of streams using BMPs.

ARS scientists are analyzing nationwide sediment data by eco-region to assess stream impairment.



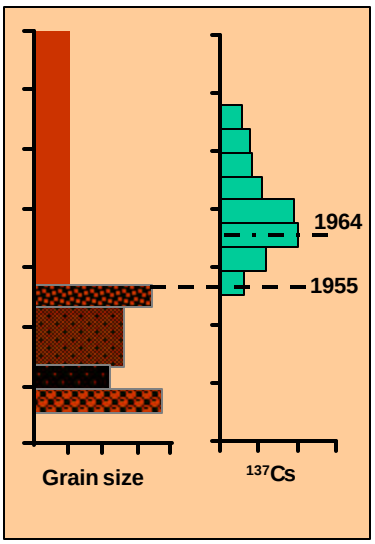


9g. Rehabilitating our Nation's Flood Control Reservoirs

The Since 1948, the USDA-NRCS has constructed over 10,000 flood control dams across the U.S. These structures represent a $14 billion investment, and yield nearly $1 billion in benefits annually. But many of these reservoirs are filling with sediment. To make these structures last another 100 years, the quantity and the quality of the sediment impounded in these reservoirs must be determined before any rehabilitation strategy can be designed.

Technologies and methodologies are currently available for the rapid and cost-effective characterization of the sediment within a reservoir. Continuous sediment cores can be extracted using a vibracoring system, chemical analysis can be performed to assess sediment quality and rates of sedimentation, and geophysical surveys can be conducted to define the subsurface distribution of sediment. These techniques are extremely effective in the assessment of sedimentation issues necessary for dam rehabilitation and watershed management.

The USDA-NRCS flood control dams service many small tributaries in over 2000 watersheds across the Nation.



By measuring the amount of radioactive cesium, the sediment within a core can be dated.

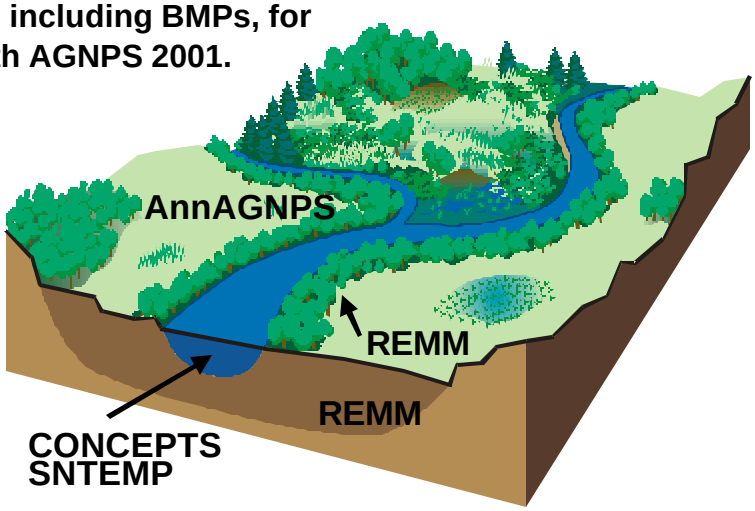
A vibracorer can obtain sediment cores as long as 4 meters in water as deep as 20 meters.

9h. Modeling Watershed Processes using AGNPS

The Agricultural Non-Point Source Pollution Model, AGNPS 2001, is a partnering project with USDA Natural Resources Conservation Service and Agricultural Research Service involving a system of computer models developed to predict nonpoint source pollutant loadings within agricultural watersheds. This technology is used to evaluate the impact of best management practices (BMPs) on the water quality within a watershed. The AGNPS 2001 watershed system models the interaction of processes that are important in assessing sources of sediment. Loadings from the fields are simulated by AnnAGNPS. Pollutant loading transport occurs through riparian zones, simulated by using REMM. As pollutants enter the channel system, CONCEPTS simulates the channel evolution, SNTEMP simulates the water temperature, and CHARIMA simulates the transport of chemicals, along with the reburial of sediments. The information from these modeling components can be used to evaluate the sources of sediment and any impact control measures may have on sediment yield and TMDLs at the watershed scale.

An example of diverse land use, including BMPs, for watershed scale applications with AGNPS 2001.

The AGNPS 2001 system of modeling components for various watershed processes.



10. Ecology and Water Quality Research

With in the last two decades public attitude toward aquatic resources has dramatically changed. The same aquatic systems once viewed as areas to be exploited for agricultural and urban development are now viewed as resources to be protected and preserved. Because of this change in attitude, and because agriculture can and does have a profound impact on aquatic ecosystems, USDA is faced with the challenge of maintaining agricultural industry while at the same time protecting these important aquatic resources. Water Quality and Ecological Processes Research Unit scientists work to evaluate the impact of erosion and agricultural runoff (sediments, nutrients, chemicals) upon aquatic life, particularly indicator species, general water quality and habitat of downstream water bodies. Research focuses on developing new technologies and best management practices to reduce detrimental effects of agricultural runoff. These new technologies and practices will provide farmers with the tools necessary to meet Total Maximum Daily Load (TMDL) and nutrient criteria goals while maintaining productivity and economic viability.

Water quality sampling on Deep Hollow Lake, MS.

10a. Little Topashaw Creek Project

Little Topashaw Creek, a tributary of the Yalobusha River, is typical of thousands o kilometers of streams in the American Southeast and Midwest that are experiencin rapid bed and bank erosion. These streams cause problems including loss of farmland, damage to roads and bridges, and destruction of river habitat. In cooperation with the Corps of Engineers and the NRCS, NSL research is focused o finding low-cost, environmentally-friendly ways of stabilizing these streams, and reducing the amount of sediment emanating from their banks. This includes studi of streambank and bed-erosion processes, the use of woody debris for low-cost channel stabilization and habitat restoration, new methods of bank stabilization su as the use of solar-powered pumps to dry out banks, thereby increasing bank strength, and the use of vegetation to control gully erosion. Preliminary results show that failing streambanks can be stabilized by a combination of large woody debris structures that reduce erosion and trap sediment at the base of banks while bank strength is increased by the pumping of water from the bank mass.

Large woody debris protects channel banks from erosion and restores valuable river habitats.

Stiff grass hedges are used to prevent erosion and trap sediment where farmland drains into streams.

Recording bank-retreat rate to measure the effectiveness of bank stabilization by solar-powered pumps.

10b. Willows for Stream Restoration

Willow trees (*Salix* spp.) are hardy, flood-tolerant plants native to most parts of North America. Willows are often used to stabilize eroding stream banks because they can be propagated by planting cuttings rather than seed. The cuttings, which may be as large as poles or posts, are less likely to be washed away by new erosion after planting than seed or smaller plant materials. As they establish and grow, willows shield banks from high velocities, induce sediment deposition instead of erosion, and thus create conditions favorable for other riparian plants to naturally establish.

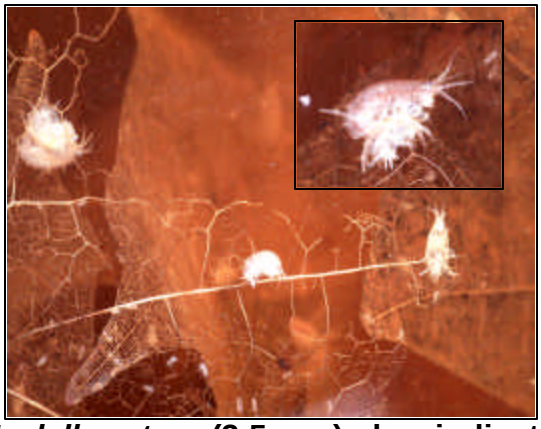
Use of willow cuttings on severely eroded stream banks has met with mixed success. In collaboration with the University of Memphis and the U.S. Corps of Engineers, the NSL has studied the factors that control willow cutting survival and growth in the field and in the laboratory. Results indicate that the cuttings are quite sensitive to soil moisture and texture. Additional work at NSL has examined the effects of arrays of willow posts planted in a straight channel on the velocity patterns that produce restoration of natural meandering and the effect that willow roots have on the strength of bank soils.

Dormant willow posts are planted in degraded streams and their growth and survival are monitored.

10c. Mississippi Delta MSEA Project

The purpose of the Mississippi Delta Management Systems Evaluation Area (MDMSEA) project is to develop and evaluate economical, environmentally sound farm practices that improve water quality and ecological health by reducing soil erosion and associated contaminants leaving agricultural fields in surface runoff. Initiated by the NSL in 1994, project research collaborators include USGS, Jackson, MS; ARS Stoneville, MS; the Mississippi Water Resources Research Institute; and the Delta Branch of the Mississippi Agricultural and Forest Experiment Station. In addition to numerous farmers, cooperators include more that 15 other federal, state, and local agencies and/or interested agricultural groups.

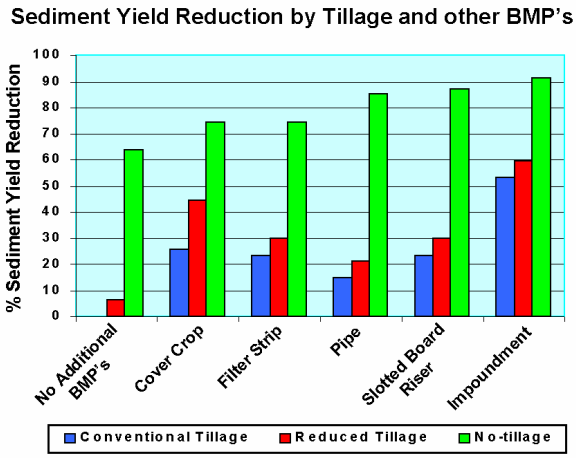
MDMSEA evaluates a variety of preventive practices in both within field and edge-of-field flow zones. MDMSEA primary research sites are three oxbow lake watersheds located in Leflore and Sunflower counties. The AGNPS 2001 modeling system is used to evaluate the short and long-term impact of alternate BMPs on sediment yield and water quality from these watersheds.



***Hyalella azteca* (3-5 mm): key indicator organism for sediment quality**

Collection of bottom sediment from oxbow lake

Instrumented slotted-board riser pipe for edge-of-field water quality



10d. Improving Lake Water Quality for Sports Fishing Through the Use of Best Management Practices

Natural lakes of the Mississippi Delta, long known for their productivity and recreational value have declined in popularity as recreational resources because of poor water quality and fisheries. Sediment from agricultural runoff interferes with the plankton that is the foundation of all life in freshwater lakes. This research demonstrated that Best management practices (BMPs) reduce sediment-laden runoff and improve water clarity, thus boosting plankton growth that is necessary for a good sports fishery. Water quality improved in two lakes whose watersheds were protected with cultural based BMPs such as conservation tillage and cover crops. An oxbow protected with structural measures alone did not show significant improvement in water quality. Sports fish were successfully reintroduced in the two lakes whose watersheds were protected with cultural based BMPs such as conservation tillage and cover crops. These lakes also exhibited the most significant improvement in water quality. Bass populations that were lacking before renovation and restocking were successfully established. Results indicate that cultural BMPs on adjacent fields may play a more significant role in improving lake water quality and may be needed in addition to structural measures to insure improve fisheries in oxbow lakes.

Bigmouth Buffalo from Thigman Lake.

Longear Sunfish is a popular Mississippi sport fish.

10e. Agricultural Drainage Ditch Research

Many best management practices (BMPs) have been offered to help alleviate potential negative effects of agricultural storm water runoff. An often overlooked BMP is the typical drainage ditch which surrounds production acreage. Historically, these ditches have been seen only as a means for water transport off agricultural fields. Our research has shown that these ditches serve as crucial areas for agricultural contaminant transfer and transformation. Essentially, these ditches serve as buffers between production acreage and their aquatic receiving systems (e.g. lakes, rivers, streams). Recent field trials conducted on drainage ditches within the Mississippi Delta MSEA indicate that between 50 – 95% of certain herbicides and insecticides are retained in the ditch vegetation. Because of this retention, potentially harmful concentrations of these pesticides are removed from the water before they reach lakes, rivers, and streams. NSL ditch research is continuing to examine pesticide and nutrient retention in these unique ecosystems. Ditch habitat and other ecological parameters are also being evaluated in order to establish a standard ditch classification scheme. The ultimate goal of this project is to equip farmers, conservation officials, and other interested parties with ditch size and vegetation parameters which will result in efficient pesticide and nutrient trapping.

Collection of sediment in an agricultural drainage ditch.

Example of a typical agricultural drainage ditch.

Preparing to begin a simulated storm event to measure a ditch's buffering capacity for pesticides.

10f. Edge-of-field Water Quality Research

The hypothesis being tested is that improvement in edge-of-field water quality can be demonstrated via specific combinations of field management practices. Selected fields in the Mississippi Delta Management Systems Evaluation Area (MSEA) watersheds are being automated to collect surface water samples from various types of field drainage pipes during all surface runoff events. Within-field practices being evaluated include: modified outlet pipes (slotted-board riser and slotted-inlet pipes, stiff-grass hedges, tile drainage, conservation tillage, and cover crops. Instrumentation is relatively simple and compact, and involves an area-velocity flow logger/meter and a scaled-down automated composite sampler. This is significantly less costly and less labor intensive than the traditional instrumentation involving a flume, larger instrument shelter, flow-measuring device (typically a stage recorder), and full-size sampler. One site is a control and the other two have switch grass (*Panicum virgatum*, Alamo variety) hedges in front of the pipe. One of these latter two has a tile drain through the switch grass hedge to reduce water ponding. Three additional sites on slotted-inlet pipes have been identified and instrumentation procured. Six additional sites, similar to those already described, are planned for another watershed.

Instrumented slotted-board riser pipe for edge-of field water quality.

Instrumented slotted-inlet riser.

10g. Using Macroinvertebrate Indicators of Water Quality

By sampling the aquatic insects of lakes, rivers, and streams, scientists can determine the relative water quality of a particular site. The presence and / or absence of certain types of bugs is often a valuable indicator of potential concern due to pollution or lack of available habitat. Additionally, field samples can be taken back to the laboratory and used in bioassays, which expose laboratory-reared organisms to site water and / or bottom sediment. Depending upon the response of these laboratory organisms, a site's overall water quality and relative ecosystem health can be predicted. This picture of information allows scientists to understand degrees of aquatic impairment and evaluate necessary recommendations for remedying problems. Such recommendations in agricultural areas must include watershed inputs and understanding how the individual stream corridor functions.

Examining a lake sediment sample for the presence of indicator species.

Collecting macro invertebrates along a debris jam in a Mississippi stream.

Amphipod (<u>Hyalella azteca</u> used in laboratory water quality bioassays.

11. Demonstration Erosion Control (DEC) Project

High annual rainfall, steep hillsides, and extremely erosive soils make northwestern Mississippi one of the most fragile landscapes in the world. The Demonstration Erosion Control Project (DEC) addresses problems associated with watershed erosion, sedimentation, flooding, and environmental degradation. DEC activities are targeted at 16 watersheds comprising 8,000 km^2 within the Yazoo River Basin of northwest Mississippi. These watersheds have suspended sediment yields about three to six times the national average, making them an ideal natural laboratory for systematic studies of erosion and sedimentation that yield valuable findings of national and global relevance.

DEC is a collaborative effort initiated in 1984 between the NSL, the U.S. Army Corps of Engineers, and the USDA Natural Resources Conservation Service. DEC activities include planning, design, construction, monitoring and evaluation to reduce flooding, erosion, and sedimentation problems by applying environmentally sound management practices. Notable advances in land treatment and soil conservation practices, stable channel assessment, streambank erosion prediction and control, stream habitat restoration, physical and computational modeling of rivers and watersheds, sediment transport mechanics, and grade control structure design have resulted from DEC-related NSL research.

Activities in the DEC Project include conservation practices on cultivated lands, stream corridor restoration, and design of grade control structures.

12. Cooperative Soil Conservation Research with MAFES, Mississippi State University 1956-2001

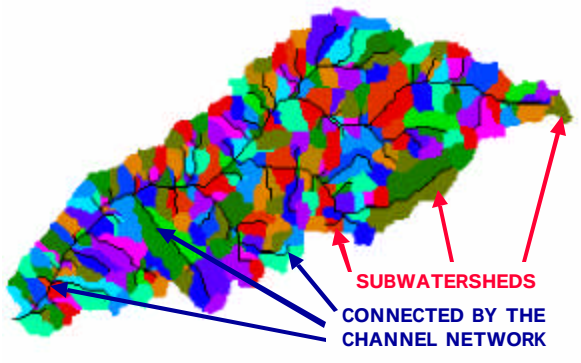
Cooperative conservation tillage research since 1956 between the National Sedimentation Laboratory and the North Mississippi Branch of the Mississippi and Agricultural Forestry Experiment Station (MAFES) at Holly Springs improved understanding of erosion-control practices for conservation planning. Early research (1956-1969) showed the erosion-control benefits of terraces, contoured graded rows, and good cropping practices versus poor management. Conservation tillage studies (1970-2001) with soybeans, corn, grain sorghum, and cotton showed that no-till and reduced-till cropping systems dramatically reduce erosion in the southern United States. For many years, the only research in the southern United States to determine the soil erosion effectiveness of no-till conservation tillage practices was conducted at Holly Springs. The USDA-NRCS used these research data to help set specifications and criteria for conservation tillage systems throughout the United States. The ARS and NRCS also used these data to help refine erosion prediction technology used by USDA to ensure compliance with provisions to federal legislation in the 1985 and 1990 Farm Bills, and to improve and validate the USLE, RUSLE, and WEPP erosion models. Continuing studies enable conservationists to help farmers nationwide to use their land productively and profitably.

Effectiveness of stiff-grass hedges at edges of cotton (left) and corn (right) fields at trapping sediment is being addressed, along with several other crop and land management systems, at the MAFES experiment station at Holly Springs.

13. Cooperative Research on Watershed Simulation with the National Center for Computational Hydroscience and Engineering, University of Mississippi

Cooperative research between the NSL and the National Center for Computational Hydroscience and Engineering (NCCHE), University of Mississippi has been ongoing since the early 1990's. This research has focused on the integration of what happens to the pollution produced from the agricultural fields of a watershed as that pollution travels into the watershed channels and affects points downstream. The NSL and NCCHE have linked USDA watershed simulation technology with NCCHE channel evolution technology to provide planning information tools to watershed managers that are needed to assess the water quality, environmental and ecological impacts of best management practices (BMPs) used throughout the watershed. Alternative BMPs can be evaluated and recommended with this technology to determine the impact of agricultural and channel erosion control measures on the entire ecosystem of the watershed. Another area of research cooperation has involved studying spur dikes placed within watershed degraded streams, which are good for protecting stream banks and providing stable stream-pool habitat. These studies will yield better understandings of the physics of the flow and erosion near spur dikes and yield an excellent test of the NCCHE two and three dimensional models.

SIMULATION WATERSHED DESCRIPTION



Streamflow within each basin within a watershed can be simulated using numerical models.

School of Engineering, University of Mississippi.

14. Cooperative Research on Acoustic Technology with National Center for Physical Acoustics, University of Mississippi

Accurate measurements of soil physical properties and prediction of sediment movement in agricultural lands is required for selecting appropriate control measures for sediment erosion. Yet current measurement techniques are time consuming, labor intensive, and expensive. Many federal, state, and local agencies, which require data on soil properties and on movement of sediment, do not have the funds necessary to obtain the information they need.

A cooperative project between researchers at the NSL and the National Center for Physical Acoustics (NCPA), University of Mississippi has been in progress for ten years. The goal of this project has been to explore and apply acoustic technology to automate and improve measurement of soil properties and sediment movement in agricultural watersheds in a cost effective manner. During this project, new techniques and instruments to measure the physical properties of soils and to measure the sizes and amounts of sediment being carried by streams have been successfully developed. These techniques have the advantages of being less disruptive, of reducing the time needed to obtain useful information, and of requiring significantly less labor than conventional methods.

A specially designed flume has been used to test and validate acoustic imaging of the transport of suspended solids.

NCPA, University of Mississippi.

15. Cooperative Research with the University of Mississippi's Biological Field Station and Center for Wetland Research Seek TMDL Solutions

Collaborative research with the University of Mississippi's Biological Field Station and Center for Water and Wetland Research will take on several aspects of solving Total Maximum Daily Load (TMDL) related problems. This collaborative research includes: determining how much of a given pollutant is necessary to cause ecological impairment in streams, what types of vegetation in agricultural ditch and wetlands are most useful in improving water quality, and what types aquatic animals are the best indicators of water quality impairment and improvement. This research will provide EPA, the Mississippi Department of Environmental Quality, Farmers and Landowners with both valuable tools for assessing TMDL criteria and cost effective methods for meeting TMDL goals.

Center for Wetland Research, University of Mississippi Biological Field Station.

16. Technology Transfer

NSL scientists realize that producing world-class scientific findings is only the first part of their job. New knowledge and technology have no impact until end users become familiar with them. Accordingly, the NSL strives to disseminate its findings through many channels—the scientific literature, popular press and trade publications, oral presentations to interested groups, and even one-on-one conversations with producers, resource managers or anyone else with an interest in soil and water resources. Field days and site visits are essential opportunities to interact with stakeholders in the real-world arena. The NSL website provides avenues to learn more, contact individual scientists, and download the latest versions of NSL software.

17. NSL Personnel Listing

P.O. Box 1157
598 McElroy Drive
Oxford, MS 38655
Fax: 662-232-2915
Website: http://msa.ars.usda.gov/ms/oxford/nsl/

M.J.M. Römkens, Ag. Engineer/Soil Scientist
Laboratory Director
Research Leader, Upland Erosion Processes
Phone: 662-232-2940
Email: mrömkens@msa-oxford.ars.usda.gov

Research Leaders

C.V. Alonso, Hydraulic Engineer
Channel and Watershed Processes
Phone: 662-232-2969
Email: calonso@msa-oxford.ars.usda.gov

M.A. Locke, Soil Scientist
Water Quality and Ecological Processes
Phone: 662-232-2908
Email: mlocke@msa-oxford.ars.usda.gov

Research Scientists

R.L. Bingner, Agricultural Engineer
Phone: 662-232-2966
Email: rbingner@msa-oxford.ars.usda.gov

C.M. Cooper, Ecologist
Phone: 662-232-2935
Email: ccooper@msa-oxford.ars.usda.gov

R.F. Cullum, Agricultural Engineer
Phone: 662-232-2976
Email: bcullum@msa-oxford.ars.usda.gov

S.M. Dabney, Agronomist
Phone: 662-232-2975
Email: sdabney@msa-oxford.ars.usda.gov

D. DiCarlo, Physicist
Phone: 662-281-5705
Email: ddicarlo@msa-oxford.ars.usda.gov

S.S. Knight, Ecologist
Phone: 662-232-2934
Email: sknight@msa-oxford.ars.usda.gov

M.T. Moore, Ecologist
Phone: 662-232-2955
Email: mtmoore@msa-oxford.ars.usda.gov

F.E. Rhoton, Soil Scientist
Phone: 662-232-2938
Email: frhoton@msa-oxford.ars.usda.gov

F.D. Shields, Jr., Hydraulic Engineer
Phone: 662-232-2919
Email: dshields@msa-oxford.ars.usda.gov

A. Simon, Geologist
Phone: 662-232-2918
Email: asimon@msa-oxford.ars.usda.gov

S. Smith, Chemist
Phone: 662-232-2936
Email: ssmith@msa-oxford.ars.usda.gov

C. Wilson, Geologist
Phone: 111-111-1111
Email: cwilson@msa-oxford.ars.usda.gov